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Pore-scale origin of flow-induced bio-aggregation

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Microbes in natural and engineering systems are often found as aggregates consisting of microbial communities, organic and inorganic matters, and water. Such bio-aggregates play important roles in shaping biogeochemistry of soil and groundwater environments, clogging of porous media, biofilm formation, and human lung infections [1 –3]. In addition, aggregated cells are reported to have enhanced protections against external stresses such as anti-biotics, nutrient starvation, oxidative stress, etc., helping microbes to cope with environmental changes [3]. Therefore, understanding how bio-aggregates are formed has been an active area of research in not only engineering and natural sciences but also in clinical and evolutionary standpoints. While bio-aggregates are widely generated in porous systems, the role of pore-scale flow and porous media structure on aggregation is still poorly understood. In this study, we combine microfluidics experiments and three-dimensional (3D) numerical simulations to demonstrate that the unique 3D flow structure at the constriction points of pore-throats, which is ubiquitous in porous media, induces bio-aggregate formation.

We use a single channel with a sinusoidal pore-throat as an analog for a porous system (FIG. 1A). Upon injection of an E. coli suspension (OD600 = 0.1) at a constant flow rate (0.2 µl/min), we observed the formation of bio-aggregates at the pore-throat while in a straight channel only attachment and growth were detected (FIG. 1B - D). Pore clogging and pressure build-up occur as E. coli cells aggregate, which eventually lead to the detachment and flushing of bio-aggregates. A series of laboratory and numerical experiments revealed that 3D secondary flows facilitate attachment and capture of cells at the pore-throat, inducing aggregation. We further identified a critical shear stress value (~ 1.8 Pa) below which an aggregate forms and above which biofilm streamer-like morphology is found. Finally, we show that when the shear stress at the pore-throat is maintained below the critical shear stress, the pore-throat is rapidly clogged by bio-aggregates.

Time Block Preference

Time Block A (09:00-12:00 CET)

References

[1] P. C. Baveye and C. Darnault, Proc. Natl. Acad. Sci. U. S. A. 114, E2802 (2017).
[2] A. Ebrahimi and D. Or, Glob. Chang. Biol. 22, 3141 (2016).
[3] T. Trunk, H. S. Khalil, and J. C. Leo, AIMS Microbiol. 4, 140 (2018).

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